

Black Carbon Concentration from Worldwide Aerosol Robotic Network (AERONET) Measurements

Gregory L. Schuster¹, Oleg Dubovik², Brent N. Holben², and Eugene E. Clothiaux³

¹NASA Langley Research Center, Hampton, VA, 23681, USA

²NASA Goddard Spaceflight Center, Greenbelt, MD, 20771, USA

³Pennsylvania State University, University Park, Pennsylvania, USA

INTRODUCTION

The carbon emissions inventories used to initialize transport models and general circulation models are highly parameterized, and created on the basis of multiple sparse datasets (such as fuel use inventories and emission factors). The resulting inventories are uncertain by at least a factor of 2, and this uncertainty is carried forward to the model output [Bond et al., 1998, Bond et al., 2004, Cooke et al., 1999, Streets et al., 2001]. Worldwide black carbon concentration measurements are needed to assess the efficacy of the carbon emissions inventory and transport model output on a continuous basis.

METHOD

The Aerosol Robotic Network (AERONET; <http://aeronet.gsfc.nasa.gov>) is a network of more than 180 Sun and sky scanning radiometers located at surface sites throughout the world [Holben et al., 1998]. Aerosol size distributions and complex refractive index are retrieved from the radiance scans [Dubovik et al., 2000] and included in the operational AERONET product. We determine the corresponding amount of black carbon (BC) by iteration of the Maxwell Garnett mixing rule until we achieve a minimum χ^2 difference between the AERONET complex refractive index and the complex refractive index associated with a mixture of black carbon, water, and ammonium sulfate [Schuster et al., 2005].

RESULTS AND DISCUSSION

The yearly averaged BC concentration at 46 AERONET sites is shown in Figure 1. Note that the BC retrieval represents the column loading of black carbon, so the units are mg m^{-2} ; this can be converted to more familiar units by noting that if the aerosols happen to be uniformly mixed in a 1 km boundary layer, then 1 mg m^{-2} is equivalent to $1 \mu\text{g m}^{-3}$. Figure 1 shows that the retrieval indicates the lowest BC concentrations at the remote island sites and indicates the highest concentrations at the biomass burning sites, as expected. It also indicates values that are consistent with in situ measurements in a 1 km boundary layer. We also observe a strong sea-

sonal dependence at the biomass burning sites, with instantaneous values as high at $20\text{--}30 \text{ mg m}^{-2}$ at the Mongu AERONET site (not shown).

We also retrieve the BC specific absorption at the

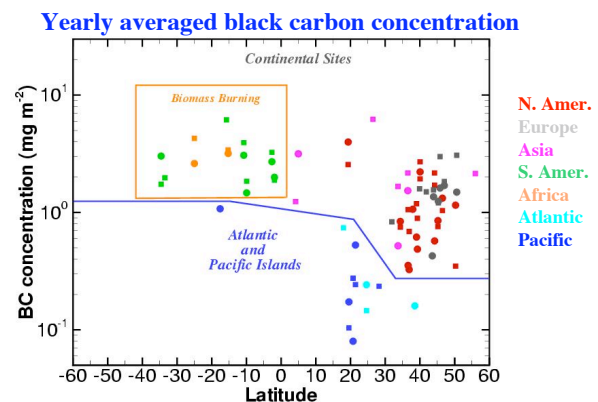


Figure 1: Yearly averaged black carbon concentration corresponding to 46 AERONET sites. Circles represent the year 2000, squares the year 2001.

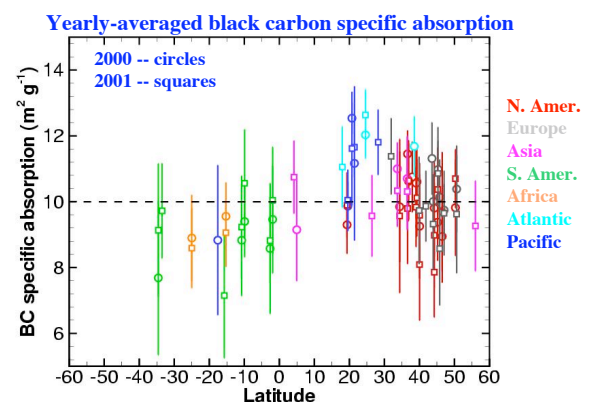


Figure 2: Yearly averaged black carbon specific absorption ($\lambda = 0.55 \mu\text{m}$) corresponding to 46 AERONET sites. Circles represent the year 2000, squares the year 2001, and whiskers indicate the standard deviations.

same 46 AERONET sites, as shown in Figure 2. The specific absorption is highly variable throughout the year, as indicated by the whiskers in Figure 2. We attribute this variability to the details of the size distributions and the fraction of black carbon contained in the aerosol mixture. We note that the average value for all 19,591 retrievals is $9.9 \text{ m}^2\text{g}^{-1}$, which is close to the $10 \text{ m}^2\text{g}^{-1}$ value frequently obtained from in situ measurements.

CONCLUSIONS

The continuous operation of AERONET enables the continual comparison of this BC retrieval to general circulation and transport model output to at over 185 sites throughout the world. Although we have not validated this retrieval with in situ measurements, the BC concentrations and specific absorptions look reasonable (both qualitatively and quantitatively).

Keywords: *Carbonaceous aerosols, Remote sensing*

References

- [Bond et al., 1998] Bond, T., Charlson, R., and Heintzenberg, J. (1998). Quantifying the emission of light-absorbing particles: Measurements tailored to climate studies. *Geophys. Res. Lett.*, 25(3):337–340.
- [Bond et al., 2004] Bond, T., Streets, D., Yarber, K., Nelson, S., Woo, J.-H., and Klimont, Z. (2004). A technology-based global inventory of black and organic carbon emissions from combustion. *J. Geophys. Res.*, 109.
- [Cooke et al., 1999] Cooke, W., Lioussse, C., Cahier, H., and Feichter, J. (1999). Construction of a 1x1 degree fossil fuel emission data set for carbonaceous aerosol and implementation and radiative impact in the echam4 model. *J. Geophys. Res.*, 104(D18):22137–22162.
- [Dubovik et al., 2000] Dubovik, O., Smirnov, A., Holben, B., King, M., Kaufman, Y., Eck, T., and Slutsker, I. (2000). Accuracy assessments of aerosol optical properties retrieved from Aerosol Robotic Network (AERONET) sun and sky radiance measurements. *J. Geophys. Res.*, 105(D8):9791–9806.
- [Holben et al., 1998] Holben, B., Eck, T., Slutsker, I., Tanre, D., Buis, J., Setzer, A., Vermote, E., Reagan, J., Kaufman, Y., Nakajima, T., Lavenue, F., Jankowiak, I., and Smirnov, A. (1998). AERONET – A federated instrument network and data archive for aerosol characterization. *Remote Sens. Environ.*, 66:1–16.
- [Schuster et al., 2005] Schuster, G. L., Dubovik, O., Holben, B. N., and Clothiaux, E. E. (2005). Inferring black carbon content and specific absorption from Aerosol Robotic Network AERONET aerosol retrievals. *J. Geophys. Res.*, 110.
- [Streets et al., 2001] Streets, D., Gupta, S., Waldhoff, S., Wang, M., Bond, T., and Yiyun, B. (2001). Black carbon emissions in China. *Atmos. Environ.*, 35:4281–4296.

This work was funded by the Earth Science Enterprise and the Clouds and the Earth’s Radiant Energy System (CERES) project. We appreciate the efforts of the AERONET team and the AERONET principal investigators.